

corvus
CORPORATION
DALLAS, TEXAS

Printed in U.S.A.
P/N 1001434

OWNER'S MANUAL

REFERENCE FORMULAS FOR

- MATHEMATICS • ENGINEERING • PHYSICS
- TRIG AND LOG TABLES
- CONVERSION TABLES

SLIDE RULE
CALCULATOR
WITH MEMORY

411

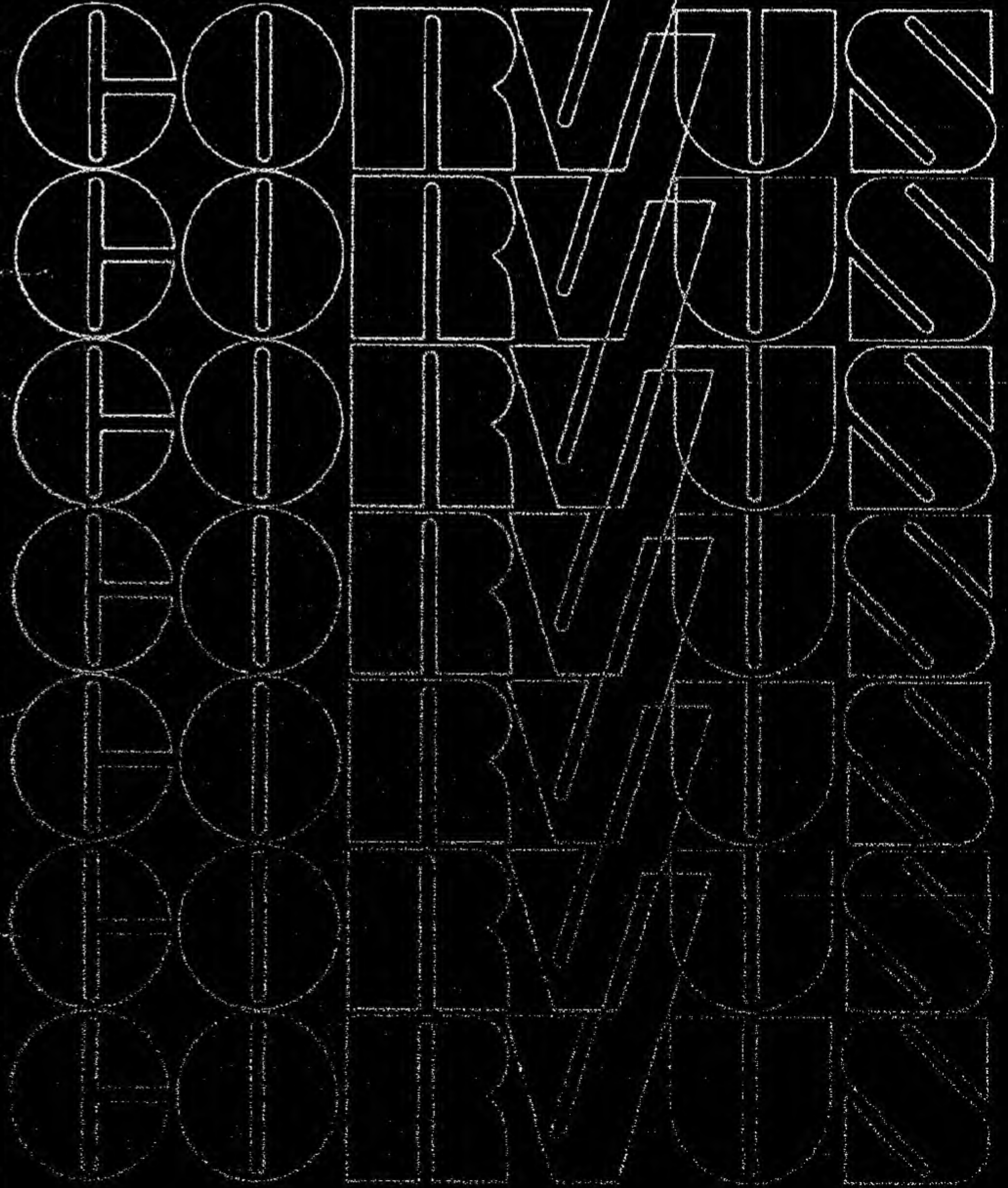


TABLE OF CONTENTS

INTRODUCTION & FEATURES.....	2
GUIDE TO THE 411	
Power Source	3
Keyboard	3
Data Entry Keys.....	3
Function Keys	3
Memory Keys	4
Scientific Notation Key.....	4
Display Description	4
Symbol Display	4
Flashing Display	4
SCIENTIFIC NOTATION	5
OPERATING THE 411	
Simple Algebraic Entry.....	6
Operating Modes	6
Accuracy	6
Overflow	6
Total Chain/Combination Capability.....	7
Automatic Clear	7
Function Key Entry Error Correction.....	7
Automatic Constant Functions.....	7-8
Raising Numbers to Powers.....	8
Negative Entry	8
Memory	8
Application of Memory Keys.....	8-9
Application of Exchange Key.....	9-10
FORMULAS & EXAMPLES	
Algebra	10-11
Geometry	12
Trigonometry	13
Electrical	14
Kinematics/Acceleration	15
Dynamics	15
Hydraulics	15
Structural	16
Moment of Inertia.....	16
Bending Moments	17
Critical Column Loads.....	18
Torsional Deflection	19
Heat Transfer	19
SAMPLE CALCULATIONS USING THE 411.....	20-22
TABLES	
Trigonometry	23
Logarithms, Common	24
Conversion Tables:	
Metric Conversions	25
Electromechanical & Temperature Conversions	26
American Conversions	27
Useful Constants & Data.....	27

INTRODUCTION AND FEATURES

The Corvus 411 — your personal slide rule with memory — is designed for the engineer, scientist, or student, to aid in accurately solving complex problems in a non-complex manner with features such as these:

- **Algebraic entry:** Problems are entered in the sequence in which they are normally written.
- **Constant:** Automatic on four functions.
- **Scientific notation:** Computes and displays numbers from $\pm 9.99999 \times 10^{99}$ to $\pm 1.00000 \times 10^{-99}$.
- **Memory:** Convenient storage of intermediate answers with easy recall and exchange features.

CORVUS: A Leader in Calculator Design

Each calculator in the CORVUS line features an MOS/LSI integrated circuit manufactured by MOSTEK Corporation. MOSTEK, the parent company of CORVUS, was the first in the world to design and market a single-chip integrated circuit for calculators. In less than $\frac{1}{4}$ square inch, this chip contained the complete capability of a four-function calculator. This breakthrough by MOSTEK in 1970 virtually revolutionized the calculator industry, allowing the design of compact, hand-held, portable units.

A similar, more advanced, MOS circuit developed by MOSTEK is used in the Model 411 to provide you with many extra calculation features and a useful memory.

Each CORVUS calculator is designed to provide extra capability to solve a wide variety of calculation applications in the home, business, office, and the field. Corvus' built-in reliability is backed by a full-year warranty on components and service.

GUIDE TO THE 411

POWER SOURCE

The 411 is powered by rechargeable nickel-cadmium batteries. The following precautions are advisable to ensure years of service from your 411:

- (1) Recharge unit when the display becomes noticeably dimmer; always avoid total discharge of batteries.
- (2) When charging unit:
 - (a) Use the supplied charger *only*.
 - (b) Turn the calculator "Off" and interconnect charger using standard household AC power.
- (3) The 411 may be operated while the charger is interconnected; however, the charging circuit will be automatically disconnected when the power switch is "On," in order to protect against accidental overcharging.
- (4) Limit charging time to 12 hours (or less if unit is used infrequently).

KEYBOARD

DATA ENTRY KEYS

- 0 through 9 — Number entry keys
- Decimal point entry key
- π Enters Pi as 3.141592 with a display of 3.14159

FUNCTION KEYS

- C **Clear:** Performs either a *total clear* or a *clear entry* (clearing displayed number only) as described below.
 1. Total clear following any function key.
 2. Clear entry following any Data Entry key(s) or Memory key(s).
 3. Clear entry of a blinking display resulting from a numeric entry overflow.
 4. Total clear of a blinking display resulting from a misoperation.
 5. Clears memory contents *only if* pressed before M/S (Memory Store).
 6. Ensures a total clear when pressed twice.
- + **"Add" key:** Instructs the calculator to complete any previous calculations and add the next numeric entry.
- **"Subtract" key:** Instructs the calculator to complete any previous calculation and subtract the next numeric entry.
- \times **"Multiply" key:** Instructs the calculator to complete any previous calculation and multiply by the next numeric entry.
- \div **"Divide" key:** Instructs the calculator to complete any previous calculation and divide by the next numeric entry.
- \sqrt{x} **"Square Root" key:** Instructs the calculator to complete any previous calculation and obtain the square root of the resultant.
- $1/x$ **"Reciprocal" key:** Instructs the calculator to complete any previous calculation and obtain the reciprocal of the result.
- = **"Equals" key:** Instructs the calculator to complete any previous calculation. Note that when the = key is used, the previously-entered number and functional command automatically become available for use as a constant. See Page 7.

MEMORY KEYS

- MS** "Memory Store" key: Instructs the calculator to store the displayed number. This automatically *replaces* any previously stored number.
- MR** "Memory Recall" key: Recalls and displays the number stored in the memory but does not "erase" the number from memory. (Non-destructive recall.)
- EX** "Exchange" key: Exchanges the displayed number with the number in memory, thus displaying the previously stored number — making it available for calculation.

NOTE: The use of any Memory key will automatically terminate any numeric entry and a "decimal point" will appear in the display.

Note that these keys *do not* complete any previous calculation and may therefore be used at any point in a chain calculation.

SCIENTIFIC NOTATION KEY

- EE** "Enter Exponent" key: Instructs the calculator that the next numeric entry will be an exponent of 10. A number is entered in Scientific Notation by entering the mantissa, pressing EE, and entering the exponent. (If exponent is negative, press \pm prior to entering exponent.)

EXAMPLE: 1.2×10^{-6} is entered: 1.2, EE, \pm , 6 .

Display will read 1.2 -06.

DISPLAY DESCRIPTION

This display is a solid-state LED (Light-Emitting Diode) display. The display is formatted as follows:



*NOTE: Sign of mantissa or exponent is understood to be positive unless negative sign appears.

SYMBOL DESCRIPTION

- Indicates a negative mantissa or exponent. The negative sign will appear immediately to the left of mantissas of less than 5 digits.
- Indicates positive Overflow (see Page 6)
- Indicates negative Overflow (see Page 6)

FLASHING DISPLAYS

A flashing display can result from two conditions:

Entry Overflow: A numeric entry of more than 6 digits in the mantissa. Display will flash 6 digits.

Misoperation (or Illegal Operation): Attempting an operation such as taking the square root of a negative number results in a flashing display of the last "legitimate" resultant or entry. For example: Attempting $\sqrt{6} (-3)$ will result in a flashing "-18".

SCIENTIFIC NOTATION

"Scientific notation" is stating a number in terms of 10 raised to a power. For example, one million (1,000,000) can be stated as 1×10^6 . Similarly, 1,200 is stated 1.2×10^3 . You will note in both examples that the number in the exponent is the number of places that the decimal was moved. (Proof: $32,000$ is 3.2×10^4 (decimal moved 4 places), or $3.2 \times 10,000 = 32,000$.)

Numbers less than one are conveniently expressed by using negative exponents. For example, one-millionth (commonly called one micro), 0.000001, can be expressed as 1×10^{-6} .

In the example of .00032, expressed as 3.2×10^{-4} , it is entered in the 411 as 3.2 EE \pm 4. In the resulting display, the "3.2" is called the mantissa, and the " \pm 4" the exponent. — Note again that the exponent represents the number of places that the decimal was moved. Note also that positive and negative exponents move the decimal point in opposite directions.

Your Corvus 411 allows you to enter numbers in scientific notation with either negative or positive exponents. When entering a number in scientific notation, it is not necessary to reduce the mantissa to one "units" digit (standard scientific notation form). For example, 750 kHz is 750×10^3 Hz, since $k = 10^3$. It may be entered on the 411 as 750 EE 3. The 411 will automatically convert it to 7.5×10^5 on subsequent operations.

Advantages:

Scientific notation greatly reduces the number of keystrokes required and greatly increases the calculator's capacity for handling large numbers. For example, 1,600,000 is easily entered: 1.6 EE 6. Calculations can be made with numbers up to 9.99999×10^{99} . A standard calculator without scientific notation would require over 100 digit positions to display results within the capacity of the Model 411.

Characteristics of Scientific Notation Use & Display:

Mantissa: In standard form, the mantissa is fixed point: 1 digit with up to 5 decimal points as required. (Trailing zeros are not displayed).

Exponent sign: The sign of the exponent is understood to be positive unless the negative sign appears to its immediate left.

Entry: Entry of a problem in scientific notation is simple. Enter mantissa (see definitions above); press EE; press \pm if negative; enter exponent.

Automatic Conversion: The 411 will automatically convert to and display results in scientific notation when the result is greater than 999,999 or less than .001.

Reciprocals and Square Roots Less Than One: All reciprocals ($1/x$) and square roots (\sqrt{x}) less than unity are always expressed in scientific notation to maintain accuracy.

No "Sign Change" Required: In the 411, it is not necessary to use a "sign change" key since negative exponents are entered with the negative key. For example, 6×10^{-3} is entered 6 EE \pm 3. (See Negative Entry, Page 8.)

OPERATING THE 411

SIMPLE ALGEBRAIC ENTRY:

The Corvus 411 operates algebraically (rather than employing the so-called reverse Polish or arithmetic logic), so that you enter a problem in the same sequence that you would write it. Compare the problem $8 - 3 = 5$ in the various logics:

Arithmetic. Problem is entered in this sequence:

8, \pm/\equiv , 3, \pm/\equiv (Display is "5.")

Reverse Polish. Problem is entered as follows:

8, \pm , 3, \equiv (Display is "5.")

Algebraic. Entry is simplified.

8, \pm , 3, \equiv (Display is "5.")

The greater the complexity of a problem, the more the simplicity of algebraic entry is appreciated.

OPERATING MODES

The Model 411 has two operating modes:

"Floating Point." In this mode, calculations are entered and made just as on standard multifunction calculators, with six-digit capacity and floating decimal point. (Results exceeding this capacity are automatically converted to Scientific Notation.)

"Scientific Notation." Entries may be made directly in the scientific notation mode simply by using the EE ("Exponent Entry") key.

ACCURACY

The 411 maintains an internal 7-digit accuracy. **Round-Off:** Resultant 6-digit displays are rounded off to the nearest correct digit; e.g., an internal answer of 1.343457 would be displayed as 1.34346.

Another example is π , which is displayed as 3.14159 but internally carried as 3.141592, so that $3 \times \pi$ results in a display of 9.42478.

OVERFLOW

When a calculation results in an overflow (as noted by the appropriate symbol), the mantissa will display the most significant digits while the exponent will overflow past 10^{99} .

When the result first goes into overflow the exponent is understood to be three digits with the "hundreds" digit not shown, so that a display of $\square 8.12345 06$ is interpreted as 8.12345×10^{106} .

This overflow condition can be further calculated if desired, but by multiplication or division only and with the necessary mental corrections of the displayed exponent, since the 411 will assume the display as 8.12345×10^6 during secondary calculations.

Addition or subtraction during overflow will not calculate since either is an illegal operation. The display will be restored to the previous overflow, and flash on and off. A single pressing of the C key, in this case, performs a clear-all function.

TOTAL CHAIN/COMBINATION CAPABILITY

The Model 411 features total chain/combination capability. Each function key serves as an "equals" key to the previously entered portion of the problem. For example, in the problem $(2 + 3) \times 4$, the \times key completes the addition of 2 and 3 and sets up multiplication of the displayed "5" by the next entry, which will be 4. The reciprocal $1/x$ and square root \sqrt{x} keys not only complete their previous calculation, but also complete their respective functions. For example, $\sqrt{5 + 4}$ is entered 5, \pm , 4, \sqrt{x} . (Note \equiv is not necessary to complete calculation.)

AUTOMATIC CLEAR

The following function keys, \equiv , \sqrt{x} , and $1/x$ result in complete termination of the calculation in process; therefore, it is not necessary to "clear" the calculator with the C key before beginning a new calculation. (See also use of \equiv key in Automatic Constant Functions, below.)

Since previous calculations cannot be assumed, each sample problem illustrated throughout this manual begins with a double depression of the C key, to ensure an "all clear."

FUNCTION KEY ENTRY ERROR CORRECTION

Each functional key supersedes a previously depressed function key, for simplicity of entry corrections. The calculator will perform according to the last received instruction; for example an inadvertent striking of the $-$ key can be simply overridden by striking the $+$ key and vice versa. \times and \div act similarly as well as overriding $+$ or $-$. The \equiv command is accepted when it follows a \times or \div command, in order to allow division or multiplication by negative numbers.

E.g., 12, $-$, \times , 6 = 72. (411 has ignored \equiv command) but 144, \div , $-$, 6 = -24. (411 has accepted the entry as a negative number for division.)

An error in Exponent Entry can be corrected simply by entering the correct exponent, as the calculator accepts only the last two digits received. E.g., exponent "6" is mistakenly entered EE, 5. To correct, press 0, 6. Also, re-pressing the EE key serves as an exponent "clear."

E.g., - 12 entered as EE, 12. To correct: EE, \pm , 12.

AUTOMATIC CONSTANT FUNCTIONS

Any of the basic four functions ($+$, \pm , \div , and \times) can provide automatic constant operation when used in conjunction with the "equals" key. The second or latest, entry becomes the constant. For example, following the calculation of $2 \times 12 = 24$, the 12 is automatically available as a constant multiplier, if desired. Thus to multiply any other number of 12, such as 4, it is merely necessary to enter that number and depress the "equals" key.

Examples of using a constant divisor:

(a) $12 \div 5$			
(b) $15 \div 5$			
(c) $40 \div 5 \times 6 - 14$			
Enter	Press	Display	Note
	C, C		
12	\div	12.	
5	\equiv	2.4	Answer (a)
15	\equiv	3.	Answer (b)
40	\equiv	8.	
	\times	8.	
6	$-$	48.	
14	\equiv	34.	Answer (c)

The constant is useful when a repetitive number appears in a chain calculation, e.g., $12.5 + 8.5 + 7.0 + 7.0 + 7.0$

Enter	Press	Display
	C, C	
12.5	+	12.5
8.5	+	21.
7.0	=	28.
	=	35.
	=	42.

RAISING NUMBERS TO POWERS

This automatic constant feature makes it extremely easy to multiply a number by itself as many times as desired; that is, to raise it to the desired power, 3^4 , therefore, is simply calculated as:

Enter	Press	Display	Note
	C, C		
3	X, =	9	Second power
	=	27	Third power
	=	81	Fourth power

NEGATIVE ENTRY

The \pm key instructs the calculator that the next entry will be a negative number. For example, $6(-3)$ is entered:

$$6 \times -3 =$$

This key is also used to enter negative exponents. See "Scientific Notation," Page 5.

MEMORY

To store a displayed positive or negative number in the memory, press the MS ("Memory Store") key. (This number will replace any previously stored number.)

To recall without "erasing," (non-destructive recall) a number in the memory, press the MR ("Memory Recall") key. The memory contents will be displayed.

If it is desired to perform a calculation with the contents of the memory, depress the EX ("Exchange") key. This automatically exchanges the displayed number with the contents of the memory, allowing you to temporarily "pigeon-hole" a resultant, as well as performing calculations with the number previously stored in the memory.

To Clear Memory, press C, MS.

APPLICATION OF MEMORY KEYS MS, MR

(1) Product of Sums: $(5 + 4) \times (2 + 3) \times (6 + 7) =$

Enter	Press	Display
	C, C	
5	+	5.
4	=, MS	9.
2	+	2.
3	X, MR	9.
	=, MS	45.
6	+	6.
7	X, MR	45.
	=	585.
		8

(2) Credits/Debits: Total (add) all debits and store in memory; next, total credits; subtract debits (memory) from credits for positive or negative balance (net amount). Note that debits are still retained in memory for reference.

Example: Credits, \$18.80, \$5.35
Debits: \$9.95, \$3.94, \$7.50, \$2.98, \$4.29

Enter	Press	Display	Note
	C, C		
9.95	+	9.95	
3.94	+	13.89	
7.50	+	21.39	
2.98	+	24.37	
4.29	=, MS	28.66	Debits stored
18.80	+	18.8	
5.35	-	24.15	Credit total
	MR	28.66	Debit total
	=	-4.51	Net balance
	EX	28.66	Debit (check)
	or		
	EX	28.66	Credits in memory
	=	-4.51	Net balance
	EX	24.15	Credits (check)

(3) Storing Constant in Memory: Example of metric conversion. Known, .03937 inches = 1 mm; to solve:

- Convert 250 mm to inches: in. = constant \times mm
- Convert 99 mm to inches: in. = constant \times mm
- Convert 16 in. to mm: mm = in. \div constant

Enter	Press	Display	Note
	C, C		
.03937	MS, X	0.03937	
250	=	9.8425	Answer (a)
99	X, MR	0.03937	
	=	3.89763	Answer (b)
16	\div , MR	0.03937	
	=	406.401	Answer (c)

(4) Division of memory contents by displayed number: Assume calculation in process; 8.4 in memory; latest display is 2.8.

Enter	Press	Display
		2.8
	EX	8.4
	\div	8.4
	MR	2.8
	=	3.

APPLICATION OF EXCHANGE KEY EX

EX has many practical uses, some of which follow:

(1) Memory check: allows reference back to memory without affecting calculation. E.g., assume calculation in process, 4.5 in memory:

Enter	Press	Display	Note
12	X	12.	
	EX	4.5	Memory check & restored
	EX	12.	
4	=	48.	
		9	

(2) Update memory: Solve $a^3 + (ab) =$

Since the term a is repetitively used, it is first stored in memory as a constant. Note EX minimizes entries.

Let $a = 1.6$, $b = 1.2$

Enter	Press	Display	Note
	C, C		
1.6	MS, X	1.6	a in memory
	=	2.56	a^2
	=	4.096	a^3
	EX	1.6	a^3 in memory
	X	1.6	
1.2	+	1.92	(ab)
	MR	4.096	a^3 recalled
	=	6.016	Solution

(3) Item Accumulation: Example: (a) 4 items @ \$2.50; (b) 8 items @ \$3.75; (c) 5 items @ \$1.26. Determine each item cost (total) and total quantity of items.

Enter	Press	Display	Note
	C, C		
4	MS, X	4.	
2.5	=	10.	Cost of (a)
8	+, EX, =	12.	
	EX, X	8.	
3.75	=	30.	Cost of (b)
5	+, EX, -	17.	
	EX, X	5.	
1.26	=	6.3	Cost of (c)
	MR	17.	Total items

Note also the sample problem for geometry shown on Page 17.

FORMULAS & EXAMPLES

ALGEBRA

I. Fractions: General Rules

Addition: Add numerators only (after making all denominators common).

E.g., $2/7 + 3/7 = 5/7$; $1/3 + 3/7 = 7/21 + 9/21 = 16/21$

Subtraction: Subtract numerators only (as with addition).

Multiplication: Multiply numerators; multiply denominators; divide resultant numerators by resultant denominators.

E.g., $3/4 \times 2/3 = 6/12 = 1/2$

Division: Invert the fractional divisor and proceed as in multiplication:

E.g., $3/4 \div 2/3 = 3/4 \times 3/2 = 9/8 = 1 1/8$

II. Powers & Exponents: General Rules

Addition: When adding numbers with exponents, it is only possible to add to those numbers which have the same exponent: Add base numbers; do not change exponents.

E.g., $x^2 + 3x^2 + x^3 = 4x^2 + x^3$

Subtraction: Same rules apply as addition. Subtract base numbers with like exponents only:

E.g., $2x^2 - x - x^2 = x^2 - x$

Multiplication:

(a) Add exponents of like bases and like signs:

E.g., $x^2 \cdot x^3 \cdot y^3 = x^5 \cdot y^3$

$x^{-2} \cdot x^{-5} = x^{-7}$

(b) Subtract exponents of like bases and unlike signs:

E.g., $x^2 \cdot x^{-5} = x^{-3}$

$x^{-2} \cdot x^5 = x^3$

(c) Multiply exponents of exponents:

E.g., $(x^2)^3 = x^6$

Division: Subtract denominator (dividend) exponent from numerator (divisor) exponent (like bases only):

E.g., $x^6 \div x^2 = x^4$

$x^6 \div x^{-2} = x^8$ [Since $6 - (-2) = 6 + 2 = 8$]

Similarly, $x^{-6} \div x^2 = x^{-8}$ [Since $(-6) - 2 = -8$]

Negative Exponents: A number raised to a negative power may also be expressed as the reciprocal of that number to a positive power. Thus:

$$x^{-3} = \frac{1}{x^3} \text{ and } 2^{-3} = \frac{1}{2^3} = \frac{1}{8} = .125$$

Non-Integer Exponents: The following expressions are true:

(a) $x^{.5} = \sqrt{x}$ (b) $x^{2.5} = (x^2)(\sqrt{x})$

(c) $x^{3/4} = (x^{2/4})(x^{1/4}) = (x^{.5})(\sqrt[4]{x}) = (\sqrt{x})(\sqrt[4]{x})$

(d) $x^{1/n} = \sqrt[n]{x}$

III. Roots

Extracting a root is the reverse of raising a number to a power. For roots involving powers of 2, the following expressions are true:

(a) $^5\sqrt{x} = x^2$ (b) $\sqrt{x} = ^2\sqrt{x}$

(c) $^4\sqrt{x} = \sqrt{\sqrt{x}}$ (d) $^8\sqrt{x} = \sqrt{\sqrt{\sqrt{x}}}$

Extracting Non-Integer Roots: A unique approach is proposed allowing extraction of any root $^n\sqrt{x}$ without guesswork or approximation. Normally, the resultant is within 1/2% of the correct answer. Note that the number of \sqrt{x} steps and X , = steps must be the same. The number of steps taken determines the degree of accuracy; where less accuracy is required, fewer steps may be used.

(a) Enter number, N

(b) Perform 9 sequential \sqrt{x} operations

(c) Subtract the number 1.

(d) Divide by the desired root, n

(e) Add the number 1

(f) Square the display 9 times using \times , = repetitively.

To demonstrate the accuracy of this method, test by comparison with known cube root of $27 = 3$ ($3 \cdot 3 \cdot 3 = 27$):

Enter	Press	Display	Note
27	\sqrt{x} (9 times)	1.00646	
	-	1.00646	
1	\div	0.00646	
3	+	0.0215	3 is desired root
1	\times , =	1.00431	
	\times , = (9th time)	3.00689	Answer is "off" by .007

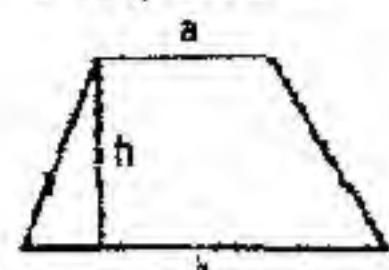
Another example: Extract $^5\sqrt{2}$ ($= 2^2 = 4$)

Enter	Press	Display
2	\sqrt{x} (9 times)	1.00135
	-	1.00135
1	\div	0.00135
.5	+	0.0027
1	\times , = (9 times)	3.98134

GEOMETRY

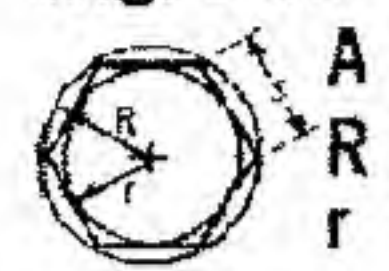
I. Plane Figures:

Trapezoid



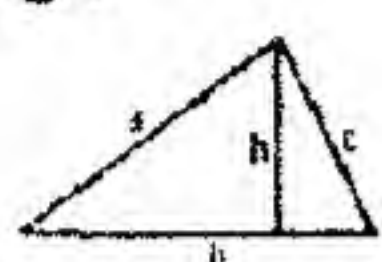
$$\text{Area} = \frac{(a + b)h}{2}$$

Reg. Hex.



$$\begin{aligned} A &= 2.598 s^2 = 3.464 r^2 \\ R &= s = 1.155r \\ r &= 0.866 s = 0.866 R \end{aligned}$$

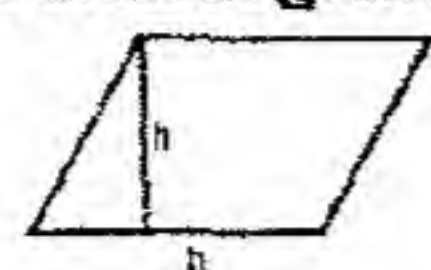
Triangle



$$\text{Area} = \frac{bh}{2} = \sqrt{s(s-a)(s-b)(s-c)}$$

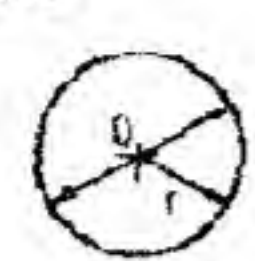
where term $s = \frac{a+b+c}{2}$

Parallelogram



$$\text{Area} = bh$$

Circle



$$\begin{aligned} \text{Area} &= \pi r^2 \\ \text{Cir.} &= 2\pi r \end{aligned}$$

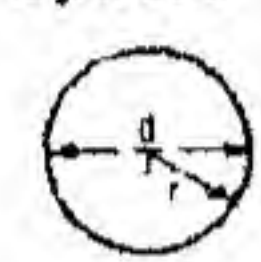
II. Solid Figures:

Cube



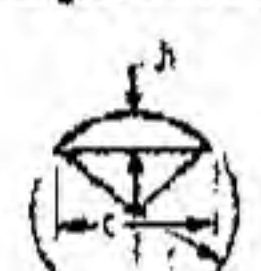
$$\begin{aligned} V &= s^3 \\ A &= 6s^2 \end{aligned}$$

Sphere



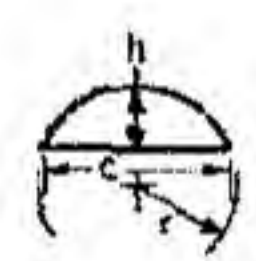
$$\begin{aligned} V &= \frac{4\pi r^3}{3} = \frac{\pi d^3}{6} \\ A &= 4\pi r^2 = \pi d^2 \end{aligned}$$

Spherical Sector



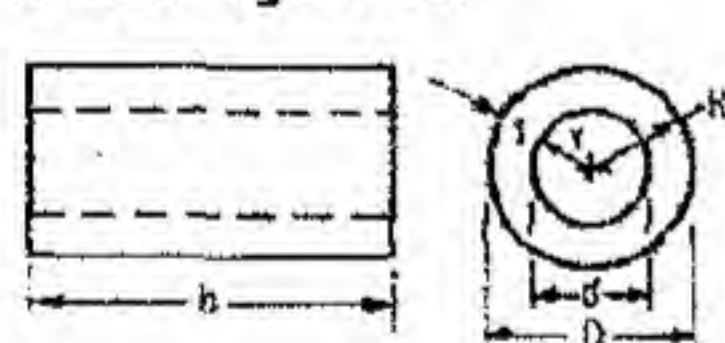
$$\begin{aligned} V &= \frac{2\pi r^2 h}{3} \\ A &= \pi r (2h + \frac{1}{2}c) \\ c &= 2\sqrt{h(2r-h)} \end{aligned}$$

Spherical Segment



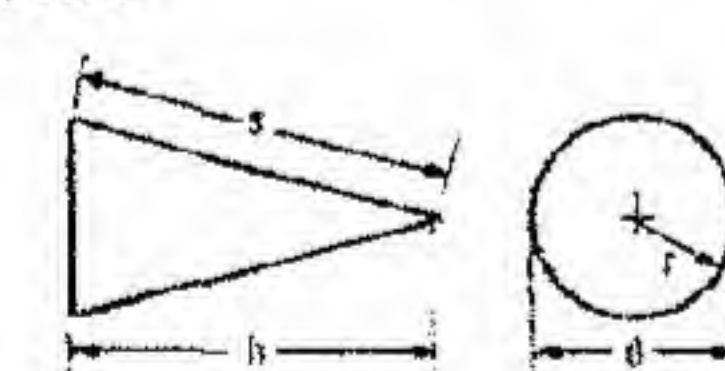
$$\begin{aligned} V &= \pi h^2 \left(r - \frac{h}{3} \right) = \pi h \left(\frac{c^2}{8} + \frac{h^2}{6} \right) \\ A &= 2\pi rh = \pi \left(\frac{c^2}{4} + h^2 \right) \\ c &= 2\sqrt{h(2r-h)} \quad r = \frac{c^2 + 4h^2}{8h} \end{aligned}$$

Hollow Cylinder



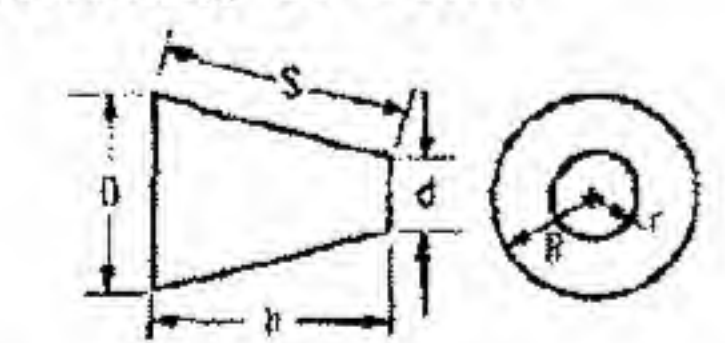
$$\begin{aligned} V &= \pi h (R^2 - r^2) = 0.7854 h (D^2 - d^2) \\ &= \pi ht (2R - t) = \pi ht (D - t) \\ &= \pi ht (2r + t) = \pi ht (d + t) \\ &= \pi ht (R + r) = 1.5708 ht (D + d) \end{aligned}$$

Cone



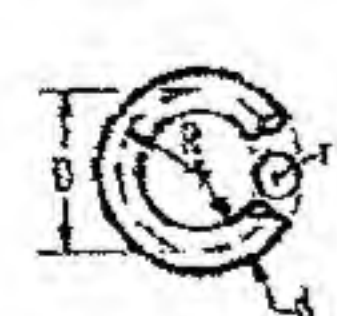
$$\begin{aligned} V &= 1.0472 r^2 h = 0.2618 d^2 h \\ A &= \pi r \sqrt{r^2 + h^2} = \pi rs \\ s &= \sqrt{r^2 + h^2} \end{aligned}$$

Frustum of Cone



$$\begin{aligned} V &= 1.0472 h (R^2 + Rr + r^2) \\ A &= \pi s (R + r) \\ s &= \sqrt{(R - r)^2 + h^2} \end{aligned}$$

Torus



$$\begin{aligned} V &= 2\pi^2 Rr^2 = \frac{\pi^2}{4} Dd^2 \\ A &= 4\pi^2 Rr = \pi^2 Dd \end{aligned}$$

TRIGONOMETRY

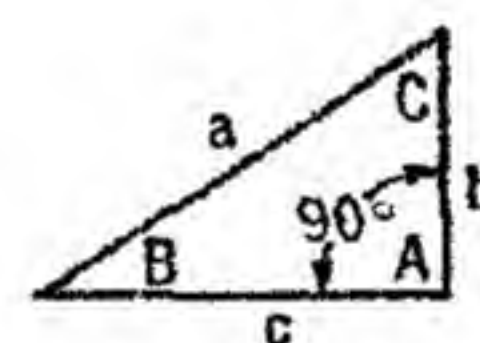
I. For any acute angle ϕ lying in a right triangle:

$$\begin{aligned} (1) \sin \phi &= \frac{\text{opp}}{\text{hyp}} \\ (2) \cos \phi &= \frac{\text{adj}}{\text{hyp}} \\ (3) \tan \phi &= \frac{\text{opp}}{\text{adj}} \end{aligned}$$

II. For angle ϕ , the following fundamental relationships are given:

$$\begin{aligned} (1) \csc \phi &= \frac{1}{\sin \phi} \\ (2) \sec \phi &= \frac{1}{\cos \phi} \\ (3) \cot \phi &= \frac{1}{\tan \phi} \\ (4) \tan \phi &= \frac{\sin \phi}{\cos \phi} \\ (5) \cot \phi &= \frac{\cos \phi}{\sin \phi} \\ (6) \sin^2 \phi + \cos^2 \phi &= 1 \\ (7) 1 + \tan^2 \phi &= \sec^2 \phi \\ (8) 1 + \cot^2 \phi &= \csc^2 \phi \end{aligned}$$

III. Solution of Right-angled Triangles



Sides and Angles Known	Formulas for Sides and Angles to be Found		
Sides a and b	$c = \sqrt{a^2 + b^2}$	$\sin B = \frac{b}{a}$	$C = 90^\circ - B$
Sides b and c	$a = \sqrt{b^2 + c^2}$	$\tan B = \frac{b}{c}$	$C = 90^\circ - B$
Side a; angle B	$b = a \sin B$	$c = a \cos B$	$C = 90^\circ - B$
Side b; angle B	$a = \frac{b}{\sin B}$	$c = b \cot B$	$C = 90^\circ - B$
Side b; angle C	$a = \frac{b}{\cos C}$	$c = b \tan C$	$B = 90^\circ - C$

IV. Solution of Oblique-angled Triangles

One side and two angles known. a, A, B	$b = \frac{a \sin B}{\sin A}$ $c = \frac{a \sin C}{\sin A} = \frac{a \sin (A+B)}{\sin A}$ Area = $\frac{ab \sin C}{2}$
Two sides and angle between them known. a, b, C	$\tan A = \frac{a \sin C}{b - a \cos C}$ $c = \frac{a \sin C}{\sin A}$ Area = $\frac{ab \sin C}{2}$
Two sides and angle opposite one side known. a, b, A	$\sin B = \frac{b \sin A}{a}$ $c = \frac{a \sin C}{\sin A}$ Area = $\frac{ab \sin C}{2}$
Three sides known. a, b, c Note: $C = 180^\circ - (A+B)$	$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$ $\sin B = \frac{b \sin A}{a}$ Area = $\frac{ab \sin C}{2}$

ELECTRICAL

I. Definition of Terms:

Symbol	Definition	Units
C	Capacitance	Farads
E	Voltage	Volts
F	Frequency	Hertz
I	Current	Amps
L	Inductance	Henries
P	Power	Watts
Q	Charge	Coulombs
R	Resistance	Ohms
t	Time	Seconds
Z	Impedance	Ohms

II. Ohm's Law (Direct Current):

$$E = IR = \frac{P}{I} = \sqrt{RP}$$

$$I = \frac{E}{R} = \frac{P}{E} = \sqrt{\frac{P}{R}}$$

$$R = \frac{E}{I} = \frac{P}{I^2} = \frac{E^2}{P}$$

$$P = EI = I^2R = \frac{E^2}{R}$$

III. Alternating Current:

$$\text{Voltage: RMS} = \frac{E_{\max}}{\sqrt{2}}$$

$$\text{Current: RMS} = \frac{I_{\max}}{\sqrt{2}}$$

$$\text{Power: } P_{\text{peak}} = (E_{\max})(I_{\max})$$

$$P_{\text{effective}} = (E_{\text{effective}})(I_{\text{effective}})$$

IV. Series/Parallel Formulas

	Series	Parallel
E_{total}	$E_1 + E_2 + E_n$	$E_1 = E_2 = E_n$
I_{total}	$I_1 = I_2 = I_n$	$I_1 + I_2 + I_n$
R_{total}	$R_1 + R_2$	$\frac{R_1 R_2}{R_1 + R_2}$
R_{total}	$R_1 + R_2 + R_n$	$\frac{1}{1/R_1 + 1/R_2 + 1/R_n}$
P_{total}	$P_1 + P_2 + P_n$	$P_1 + P_2 + P_n$
C_{total}	$\frac{1}{1/C_1 + 1/C_2 + 1/C_n}$	$C_1 + C_2 + C_n$
L_{total}	$L_1 + L_2 + L_n$	$\frac{1}{1/L_1 + 1/L_2 + 1/L_n}$

V. Capacitors/Inductors

$$\text{Inductance (L)} = \frac{X_L}{2\pi f}$$

$$\text{Inductive Reactance (X}_L\text{)} = 2\pi fL$$

$$\text{Capitance Reactance (X}_C\text{)} = \frac{1}{2\pi fC}$$

$$\text{Time Constants (t)} = RC; (t) = \frac{L}{R}$$

$$\text{Resonant Circuits: } X_L = X_C$$

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$\text{Charge (Q)} = CE = It$$

$$Q_{\text{total (series)}} = Q_1 = Q_2 = Q_n$$

$$Q_{\text{total (parallel)}} = Q_1 + Q_2 + Q_n$$

$$\text{Figure of Merit (Q)} = \frac{X_L}{R} \text{ or } \frac{X_C}{R}$$

KINEMATICS/ACCELERATION

- I. Terms: a = acceleration
g = 32.17 ft/sec²
s = distance covered in t sec.
t = time
v = velocity after t sec.
v₀ = initial velocity

II. Linear Motion (uniform):

$$s = vt$$

III. Linear Motion (v₀ > 0):

$$s = \frac{t}{2}(v_0 + v) = v_0 t \pm \frac{1}{2}at^2$$

(accelerated, +) (retarded, -)

IV. Projection:

$$v = v_0 \pm gt \text{ (downward, +; upward, -)}$$

$$s = v_0 t \pm \frac{1}{2}gt^2 \text{ (downward, +; upward, -)}$$

$$s = \frac{vt}{2} \text{ where } v_0 = 0$$

$$t = \frac{2s}{v_0 + v}$$

$$t = \sqrt{\frac{2s}{g}} \text{ where } v_0 = 0$$

V. Sliding motion on incline (excluding friction):

$$v = \sqrt{2gs}$$

DYNAMICS

- I. Terms: a = acceleration
F = force
G = weight
g = gravity
h = height
m = mass
Fa = accelerated force
s = distance
t = time
- v = tangential velocity
w = energy
w_k = kinetic energy
w_p = potential energy
p = performance
ω = angular velocity
r = radius
n = revs. per. min.

II. Linear Motion:

$$Fa = ma$$

$$w = Fs$$

$$w_k = \frac{1}{2}mv^2$$

$$P = w/t$$

$$W_p = Gh$$

III. Calculation of Mass: m = G/g

IV. Centrifugal Force: (F_z)

$$F_z = m\omega^2 r = \frac{mv^2}{r}$$

$$v = \omega r$$

HYDRAULICS

I. Specific weight γ = G/V (G = weight, V = volume)

II. Density Q = m/V = γ/g (m = mass; g = gravity)

III. Buoyancy F_a = γV

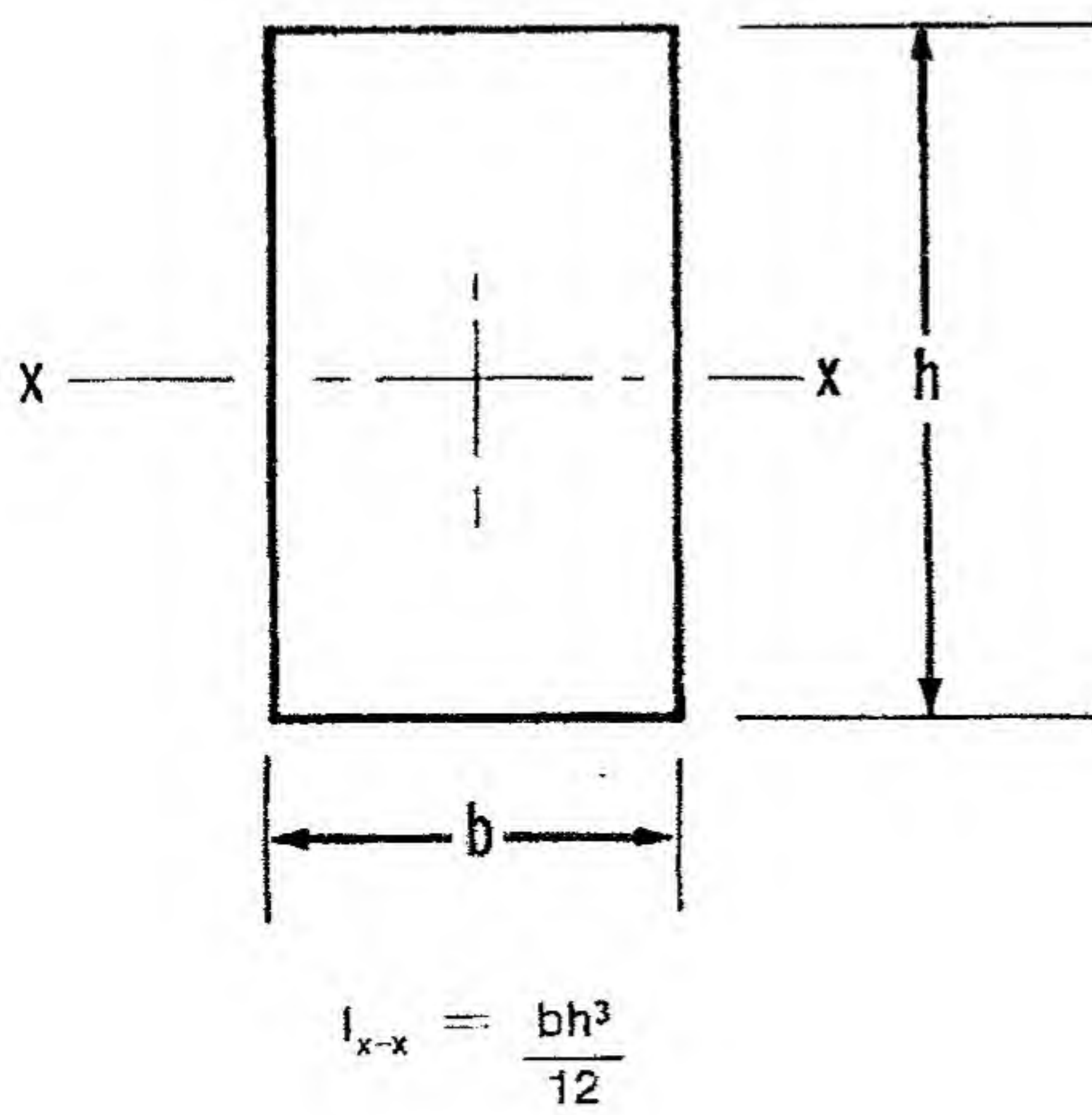
STRUCTURAL

Definition of Symbols

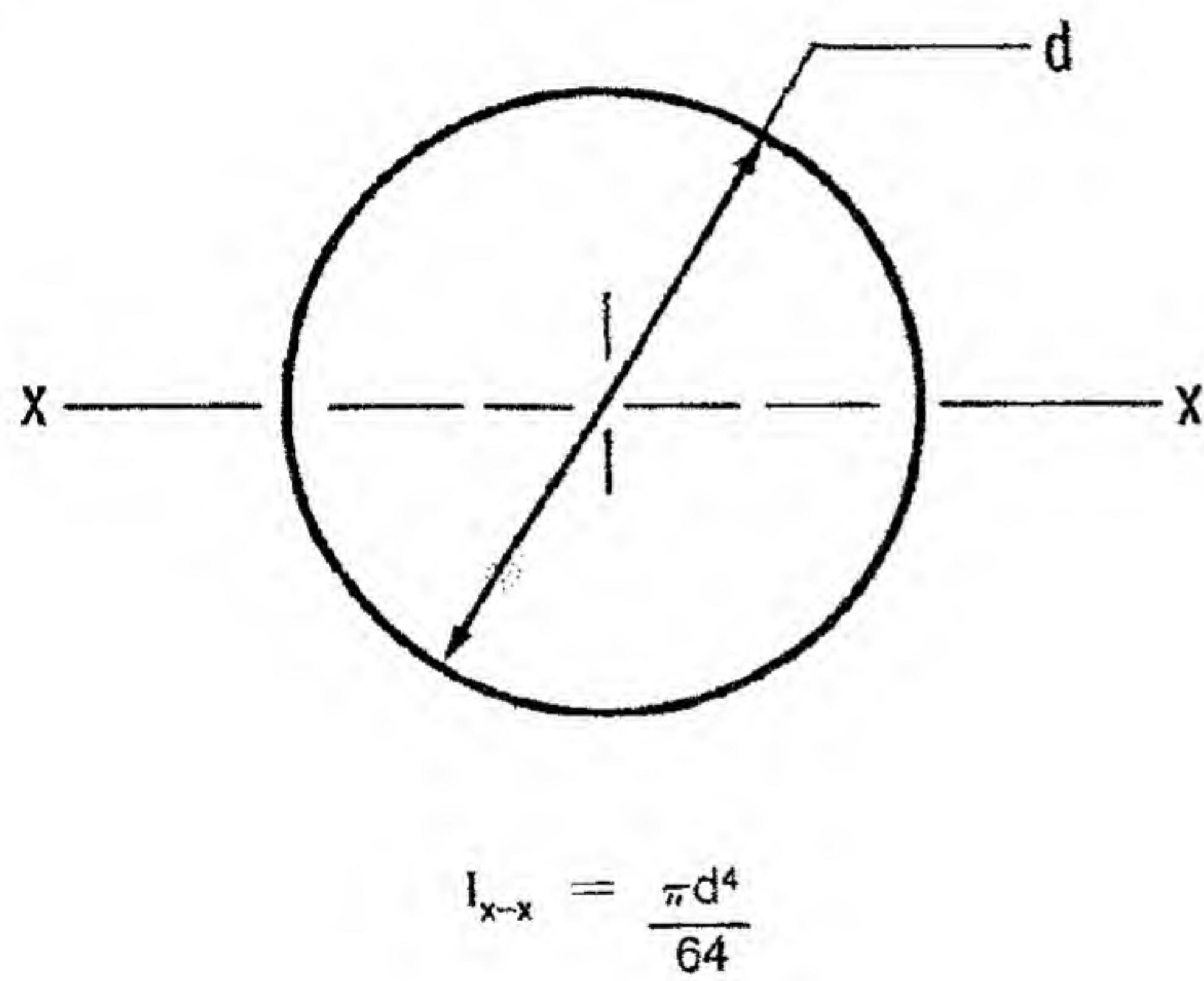
- L = Length
- M = Bending moment
- F = Concentrated load
- f = Deflection
- E = Tensile modulus
- I = Moment of inertia

MOMENT OF INERTIA OF SECTIONS

Rectangle

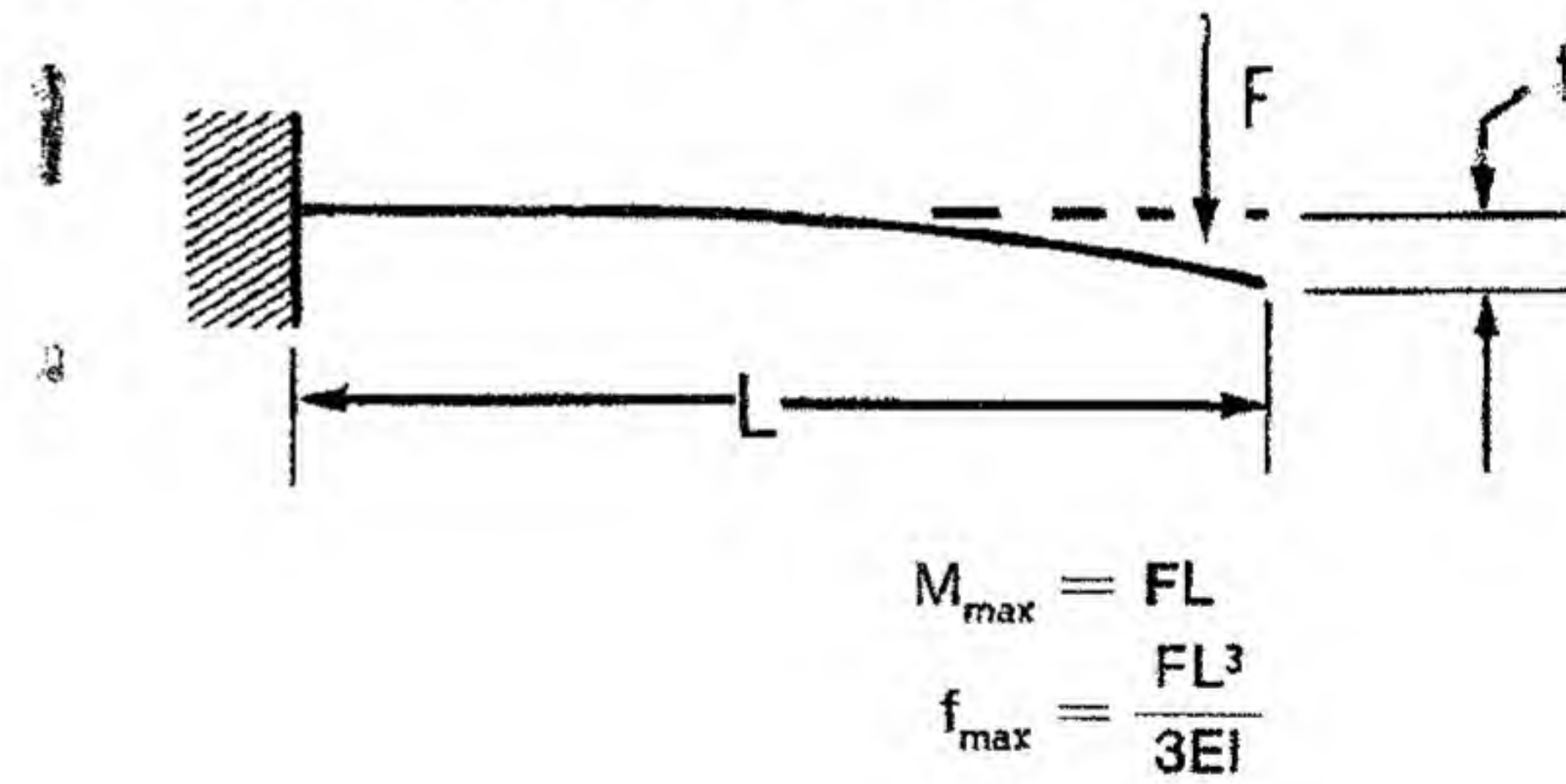


Circle

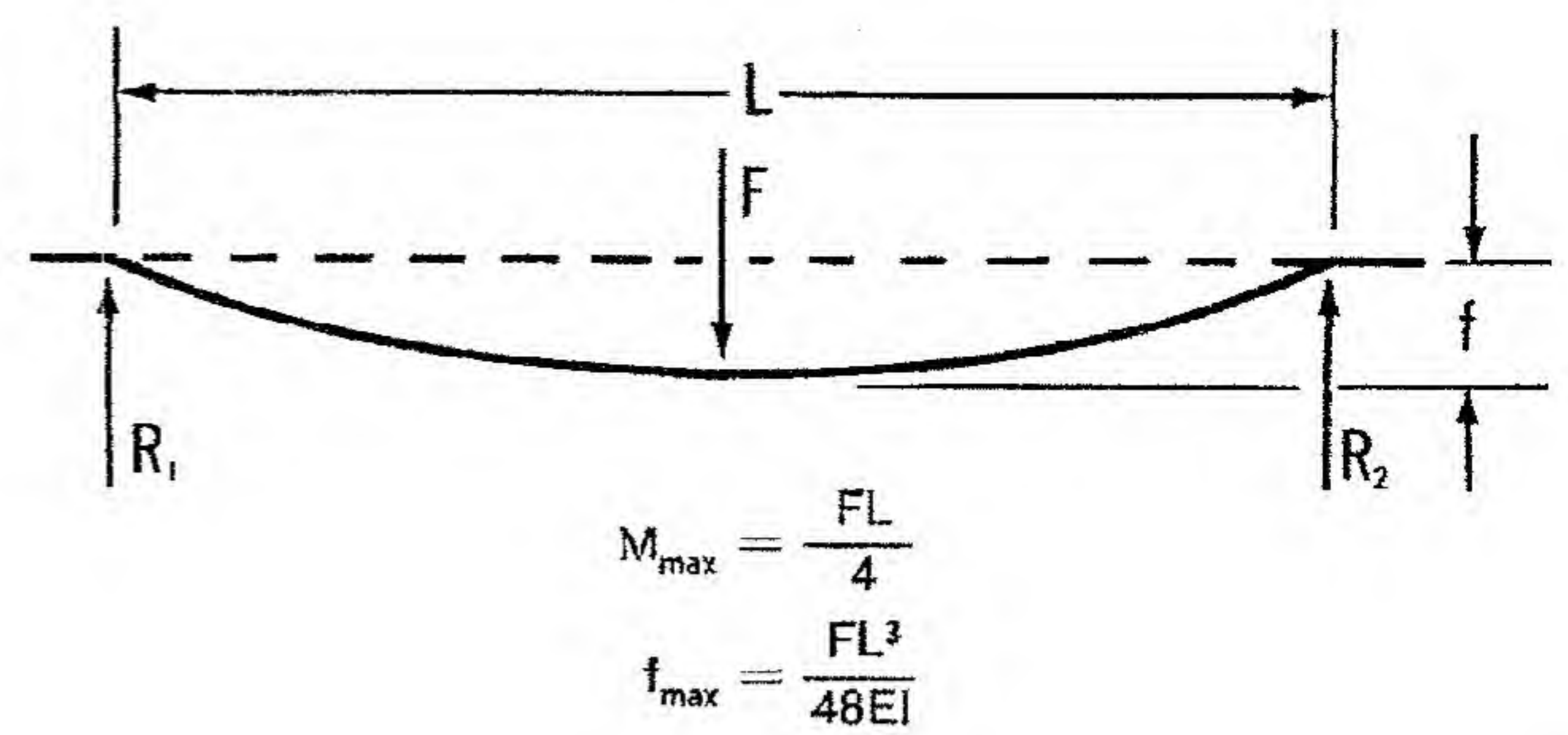


BENDING MOMENTS AND DEFLECTIONS OF UNIFORM BEAMS

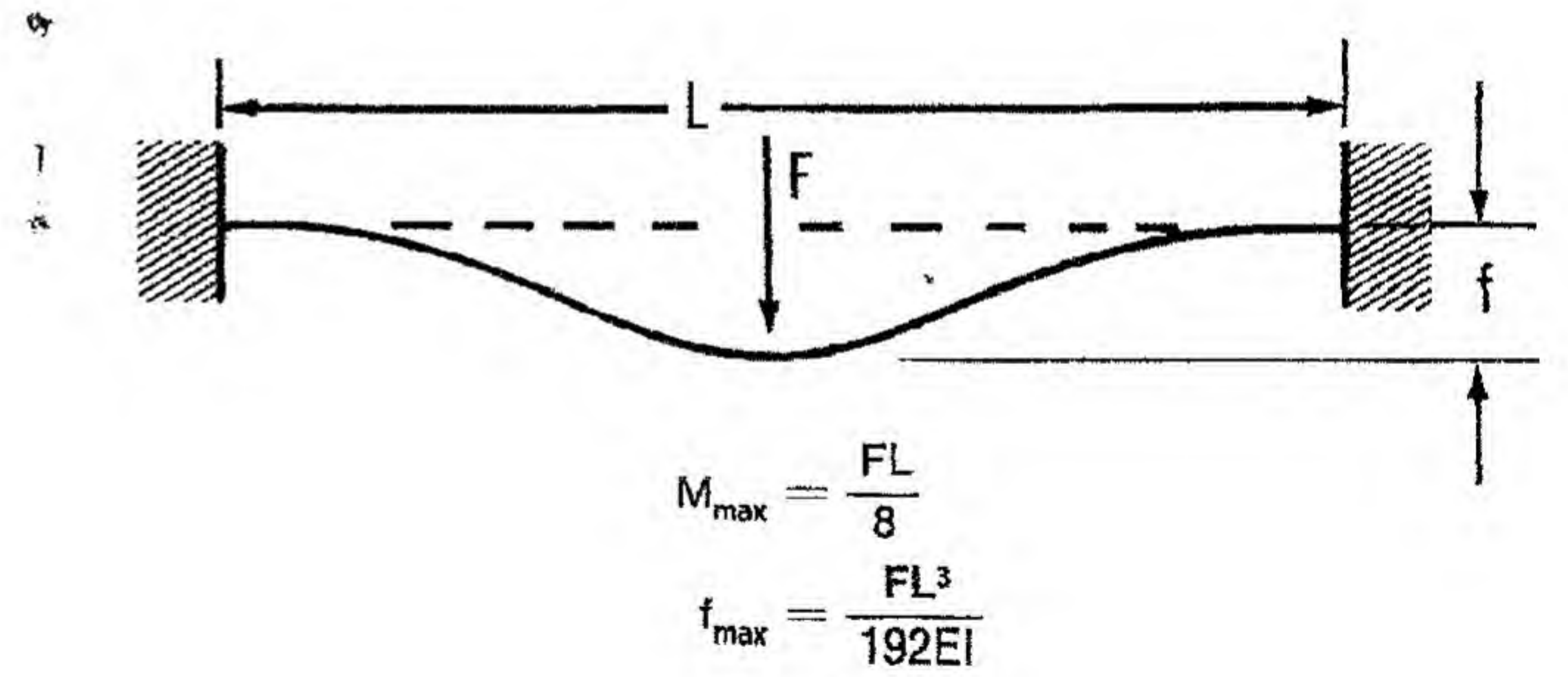
1. Cantilever Beam with End Load



2. Simple Beam, Load at Center



3. Fixed-End Beam, Load at Center

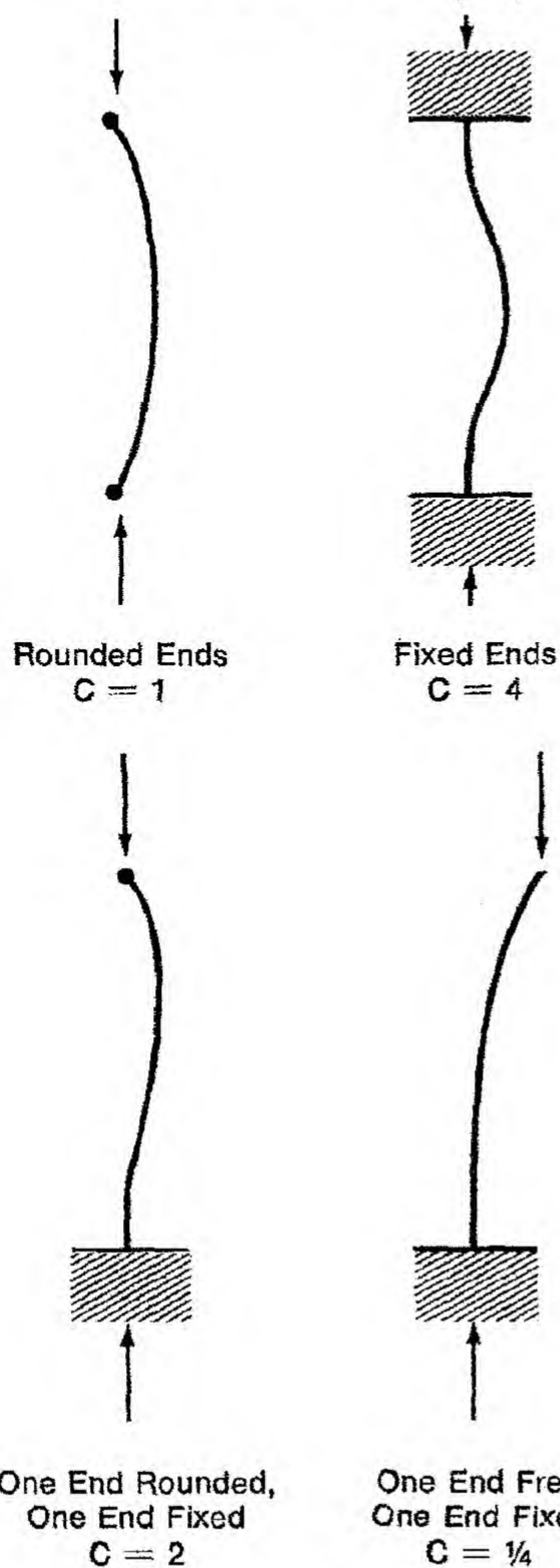


CRITICAL COLUMN LOADS

Definition of Symbols

- F_c = Critical load at which buckling occurs
 E = Tensile modulus
 A = Cross-section area
 L = Length
 I = Moment of inertia
 $k = \sqrt{I/A}$

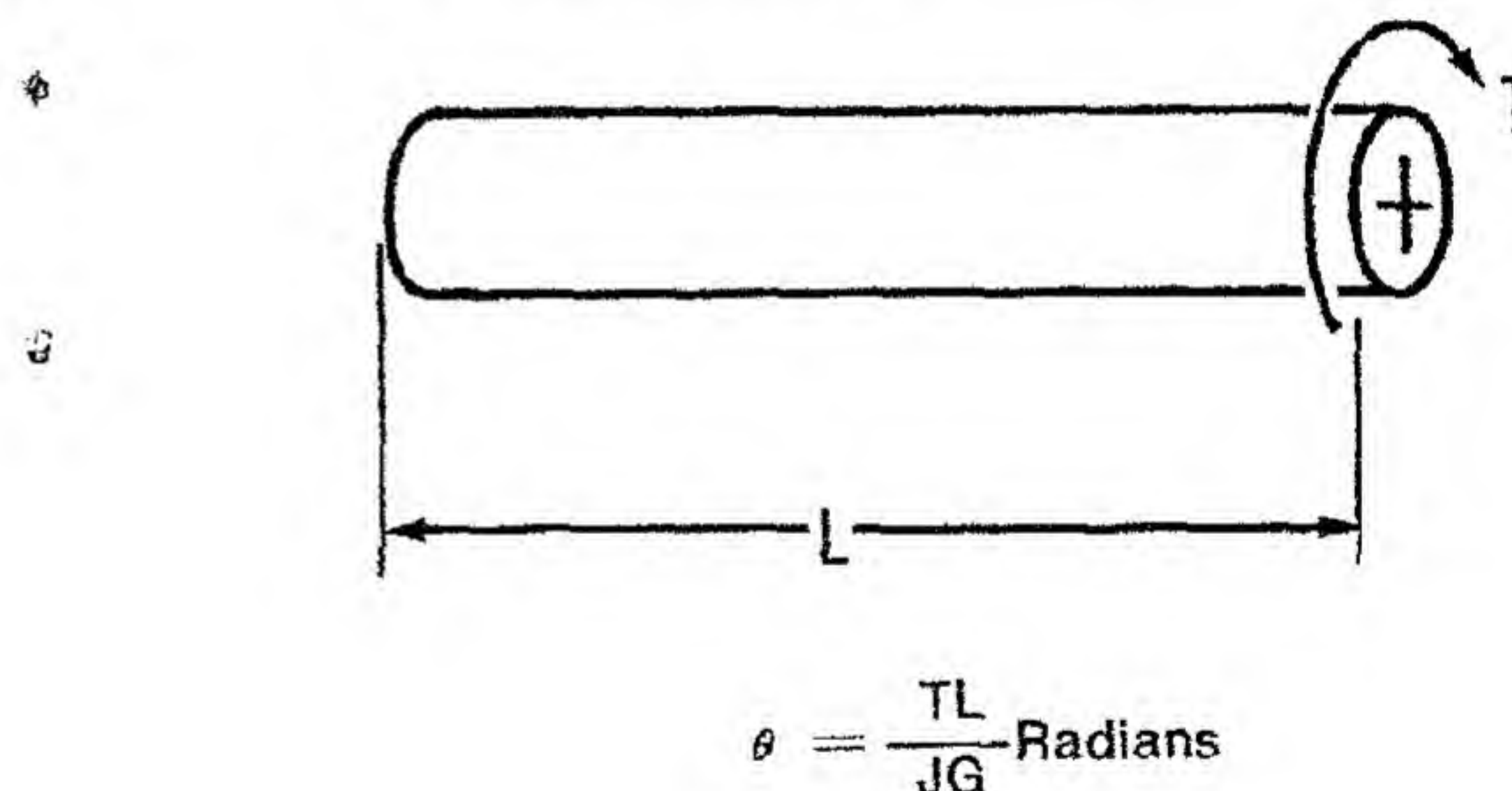
Euler's Formula: $F_c = \frac{C\pi^2 EA}{(L/k)^2}$



TORSIONAL DEFLECTIONS OF SHAFTS

Definition of Symbols

- T = Torque
 J = Polar moment of inertia
 G = Shear modulus

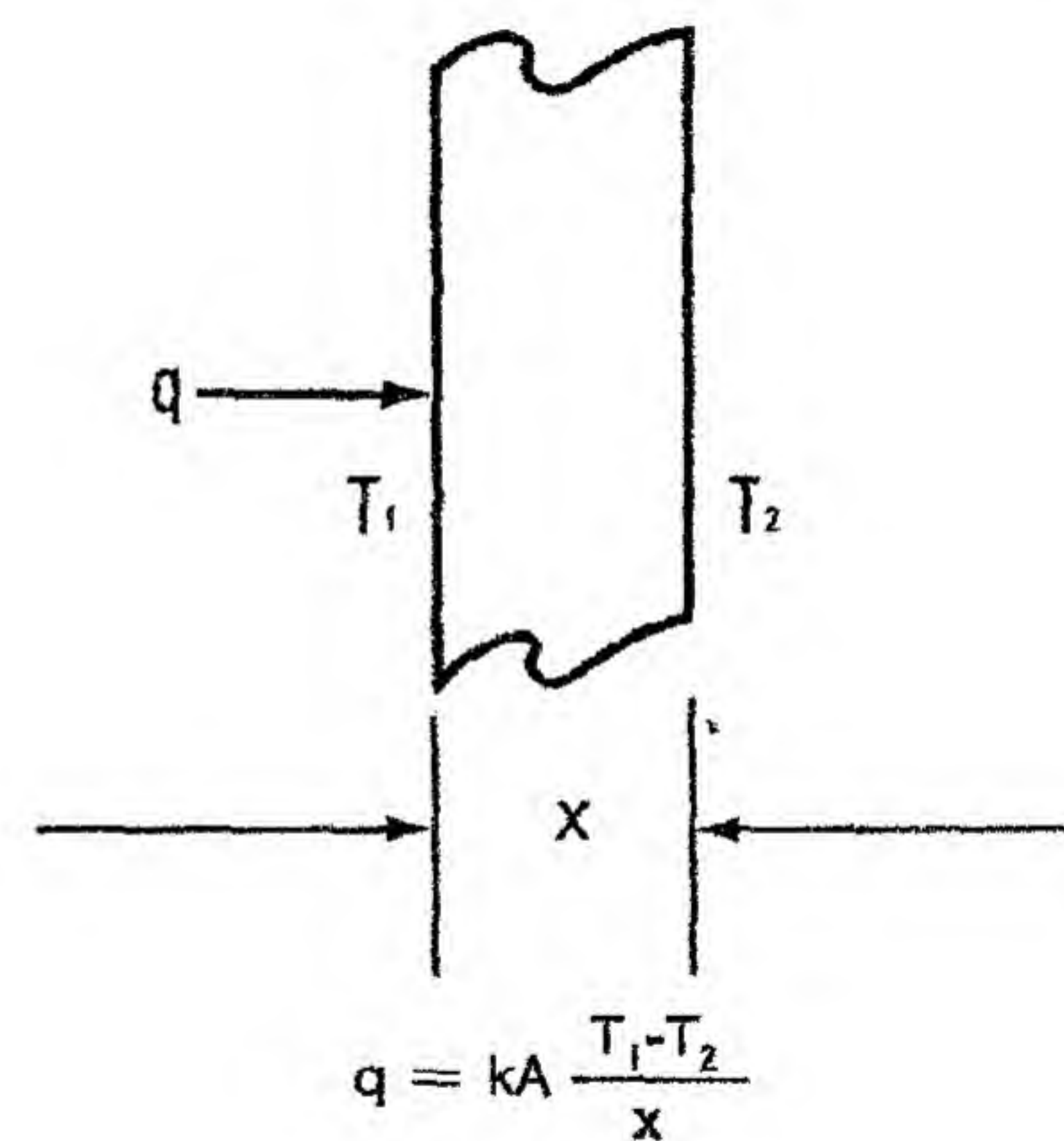


HEAT TRANSFER

Definition of Symbols

- k = Thermal conductivity of material BTU/Ft.²/hr./°F/ft.
 A = Surface area Ft.²
 T_1 = Temperature on one side of wall °F
 T_2 = Temperature on other side of wall °F
 q = BTU/Hr.

Steady-state conduction through a homogeneous plane wall



SAMPLE CALCULATIONS USING THE 411

ALGEBRA

1. Determine: $\frac{3}{4} \cdot \frac{2}{3}$

Enter	Press	Display
	C, C	
3	X	3.
2	÷	6.
4	÷	1.5
3	=	0.5

2. Determine: $[(17 + 9)6]^{.5} = \sqrt{(17 + 9)6}$

Enter	Press	Display
	C, C	
17	+	17.
9	+	26.
6	X	156.
	\sqrt{x}	12.49

GEOMETRY

1. Determine area of triangle with sides $a = 2.5$, $b = 3$, $c = 4$

$$\text{where term } s = \frac{a + b + c}{2}$$

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$

Enter	Press	Display	Note
	C, C		
2.5	+	2.5	
3	+	5.5	
4	+	9.5	= sum of sides
2	÷, MS	4.75	s, solved, in memory
2.5	X	2.25	= (s-a)
	MR, =	10.6875	= [s(s-a)]
	EX, -	4.75	Brings up s
3	X	1.75	= (s-b)
	EX, =	18.7031	= [s(s-a)(s-b)]
	EX, +	1.75	Brings up (s-b)
3	-	4.75	s restored by adding b
4	X	0.75	(s-c)
	MR, \sqrt{x}	3.74531	\sqrt{x} has simultaneously completed multiplication by 18.7031, obtaining internal (not displayed) result of 14.0273, and determined the square root

2. Determine area of a circle with a 4.5" radius where $a = \pi r^2$

Enter	Press	Display
	C, C	
4.5	X, =	20.25
	X	
π	=	63.6173

TRIGONOMETRY

1. Determine the hypotenuse (c) of a right triangle with side $a = 3$, $b = 4$

From geometry:

$$c = \sqrt{a^2 + b^2}$$

Enter	Press	Display
	C, C	
3	X, =, MS	9.
4	X, =, +	16.
	MR, \sqrt{x}	5.

2. Determine sine of the angle formed by a and c above:

$$\sin \theta = \frac{b}{c}$$

Enter	Press	Display
	C, C	
4	÷	4.
5	=	0.8

3. Convert 36° to radians where $1 \text{ radian} = \frac{180^\circ}{\pi}$

Enter	Press	Display
	C, C	
36	X	36.
180	÷	6480.
π	=	2062.65

ELECTRICAL

1. Determine total resistance (R_t) of $R_1 = 390\Omega$ in parallel with $R_2 = 570\Omega$ where:

$$R_t = \frac{R_1 R_2}{R_1 + R_2}$$

Enter	Press	Display
	C, C	
390	+	390.
570	1/x, X	0.00104
390	X	0.40625
570	=	231.563

2. Determine capacitive reactance (X_C) of a 750 kHz (f) circuit with $.01\mu\text{F}$ capacitance (C) where:

$$X_C = \frac{1}{2\pi fC}$$

Enter	Press	Display
	C, C	
2	X	2.
π	X	6.28319
750	EE	750 00
3		750 03
	X	4.71239 06
.01	EE	0.01 00
	-	0.01 -00
6		0.01 -06
	1/x	2.12207 01 (= 21 Ω)

3. Determine resonant frequency (f_o) of a .033 mH inductor (L) and a 47 μ F capacitor (C) where:

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

Enter	Press	Display
	C, C	
.033	EE, -	0.033 -00
3		0.033 -03
	X	3.3 -05
47	EE, -	47 -00
6		47 -06
	\sqrt{x}	3.93827 -05
	X	3.93827 -05
π	X	1.23724 -04
2	1/x	4.04124 03 (= 4kHz)

KINEMATICS

Use of Quadratic Equation

An object dropped from 5000' is given an initial velocity of 20'/sec. Determine time to reach the ground where:

$$s = \frac{1}{2}gt^2 + v_0t$$

$$s = \text{distance} = 5000'$$

$$g = \text{gravity } 32.2 \text{ ft/sec}^2$$

$$v_0 = \text{initial velocity} = 20 \text{ ft/sec.}$$

then,

$$5000 = 16.1t^2 + 20t, \text{ and}$$

$$16.1t^2 + 20 - 5000 = 0$$

Quadratic Equation:

$$ax^2 + bx + c = 0; \text{ then}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\text{where } a = 16.1$$

$$b = 20$$

$$c = -5000$$

$$t = \frac{-20 \pm \sqrt{20^2 - 4(16.1)(-5000)}}{2(16.1)} = 17.0125 \text{ seconds}$$

$$\text{Proof: } 5000 = 16.1(17.0125)^2 + 20(17.0125)$$

Enter	Press	Display
	C, C	
4	X	4.
16.1	X, -	64.4
5000	=, MS	-322000.
20	X, =, -, 400	
	MR, \sqrt{x} , MS, -	567.803
20	\div	547.803
2	\div	273.902
16.1	=	17.0125
(solving negative root)		
	C, -	
	MR, -	-567.803
20	\div	-587.803
2	\div	-293.902
16.1	=	-18.2548

TABLES

i Trigonometry

Natural functions of angles

Deg.	Sine	Cosine	Tangent	Cotangent	Deg.
0	0.0000	1.0000	0.0000	∞	90
1	0.0175	0.9998	0.0175	57.2900	89
2	0.0349	0.9994	0.0349	28.6363	88
3	0.0523	0.9986	0.0524	19.0811	87
4	0.0698	0.9976	0.0699	14.3007	86
5	0.0872	0.9962	0.0875	11.4301	85
6	0.1045	0.9945	0.1051	9.5144	84
7	0.1219	0.9925	0.1228	8.1443	83
8	0.1392	0.9903	0.1405	7.1154	82
9	0.1564	0.9877	0.1584	6.3138	81
10	0.1736	0.9848	0.1763	5.6713	80
11	0.1908	0.9816	0.1944	5.1446	79
12	0.2079	0.9781	0.2126	4.7046	78
13	0.2250	0.9744	0.2309	4.3315	77
14	0.2419	0.9703	0.2493	4.0108	76
15	0.2588	0.9659	0.2679	3.7321	75
16	0.2756	0.9613	0.2867	3.4874	74
17	0.2924	0.9563	0.3057	3.2709	73
18	0.3090	0.9511	0.3249	3.0777	72
19	0.3256	0.9455	0.3443	2.9042	71
20	0.3420	0.9397	0.3640	2.7475	70
21	0.3584	0.9336	0.3839	2.6051	69
22	0.3746	0.9272	0.4040	2.4751	68
23	0.3907	0.9205	0.4245	2.3559	67
24	0.4067	0.9135	0.4452	2.2460	66
25	0.4226	0.9063	0.4663	2.1445	65
26	0.4384	0.8988	0.4877	2.0503	64
27	0.4540	0.8910	0.5095	1.9626	63
28	0.4695	0.8829	0.5317	1.8807	62
29	0.4848	0.8746	0.5543	1.8040	61
30	0.5000	0.8660	0.5774	1.7321	60
31	0.5150	0.8572	0.6009	1.6643	59
32	0.5299	0.8480	0.6249	1.6003	58
33	0.5446	0.8387	0.6494	1.5399	57
34	0.5592	0.8290	0.6745	1.4826	56
35	0.5736	0.8192	0.7002	1.4281	55
36	0.5878	0.8090	0.7265	1.3764	54
37	0.6018	0.7986	0.7536	1.3270	53
38	0.6157	0.7880	0.7813	1.2799	52
39	0.6293	0.7771	0.8098	1.2349	51
40	0.6428	0.7660	0.8391	1.1918	50
41	0.6561	0.7547	0.8693	1.1504	49
42	0.6691	0.7431	0.9004	1.1106	48
43	0.6820	0.7314	0.9325	1.0724	47
44	0.6947	0.7193	0.9657	1.0355	46
45	0.7071	0.7071	1.0000	1.0000	45
Deg.	Cosine	Sine	Cotangent	Tangent	Deg.

II Logarithms

Three-Place Common Log Table

Log X	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1	.000	.041	.079	.114	.146	.176	.204	.230	.255	.279
2	.301	.322	.342	.362	.380	.398	.415	.431	.447	.462
3	.477	.491	.505	.519	.531	.544	.556	.568	.580	.591
4	.602	.613	.623	.633	.643	.653	.663	.672	.681	.690
5	.699	.708	.716	.724	.732	.740	.748	.756	.763	.771
6	.778	.785	.792	.799	.806	.813	.820	.826	.833	.839
7	.845	.851	.857	.863	.869	.875	.881	.886	.892	.898
8	.903	.908	.914	.919	.924	.929	.934	.939	.944	.949
9	.954	.959	.964	.968	.973	.978	.982	.987	.991	.996

Explanation of Table: Whole numbers are listed in left-hand vertical column with tenths of numbers in top heading, e.g., log 2.5 is derived by finding whole number 2 in left column, then moving laterally under .5 heading so that $\log 2.5 = .398$.

Since $1 = 10^0$ and $10 = 10^1$, then any number between 1 and 10 may be expressed as a power of ten whose exponent is between 0 and 1 (or fractional); as is the case with $\log 2.5 = .398$, then $2.5 = 10^{.398}$.

With this in mind any number may be derived from the table:

- (1) log 25 is broken down to powers of ten or
 $\log 25 = \log 2.5 \times \log 10$, then
 $\log 2.5 = .398$ and $\log 10 = 1.000$, so
 $25 = 10^{.398} \times 10^1 = 10^{.398+1} = 10^{1.398}$
- (2) $\log 250 = \log 2.5 \times \log 100 = \log 2.5 \times \log 10 \times \log 10 = 10^{.398+1+1} = 10^{2.398}$
- (3) $\log .25 = \log 2.5 \times 10^{-1} = 10^{.398-1} = 10^{-.602}$
- (4) $\log X = 3.881$
 $X = 10^{3.881}$
 $X = 10^3 \times 10^{.881}$
 $X = 1000 \times 7.6$
 $X = 7600$

CONVERSION TABLES

In the following tables, first look up either of the units to be converted in the left-hand column (alphabetical order). Note that the top headings indicate conversion left to right by multiplying the lefthand unit by the factor. The bottom headings convert right to left by dividing the righthand unit by the factor. Example: 35 HP = X Watts; then, 35 HP x 746 (factor) = 26,110 Watts.

METRIC CONVERSIONS

To Convert	Multiply By	To Obtain
Acres	4047	Sq. meters
Acres	160	Rods
Ares	100	Sq. meters
Centimeter	.3937	Inches
Cm./sec.	1.969	Feet/min.
Cubic feet	28.32	Liters
Cubic inches	.01639	Liters
Cubic meters	1,000	Liters
Drams	1.7718	Grams
Fathoms	1.8288	Meters
Feet	30.48	Cm.
Furlongs	.125	Miles
Gallons	3.785	Liters
Gallons (Imp.)	1.20095	Gal. (U.S.)
Grams	.03527	Oz.
Grams	.03215	Oz. (troy)
Hectares	2.471	Acres
Inches	2.54	Cm.
Kilometer	.6214	Miles (st.)
Knots	1.8532	Kilometer/hr.
League	3.0	Miles
Quarts (liq.)	946.4	Cu. cms.
Rods	5.029	Meters
Rods	16.5	Feet
Sq. inches	6.452	Sq. cms.
Tons (metric)	2205	Pounds
To Obtain	Divide By	To Convert

Orders of Magnitude

Prefix	Abbreviation
Pico = 10^{-12}	p
Nano = 10^{-9}	n
Micro = 10^{-6}	μ
Milli = 10^{-3}	m
Centi = 10^{-2}	c
Deci = 10^{-1}	d
Deka = 10	da
Hecto = 10^2	h
Kilo = 10^3	k
Mega = 10^6	M

Therefore, a centimeter is one-hundredth of a meter, etc.

ELECTRO-MECHANICAL CONVERSIONS

To Convert	Multiply By	To Obtain
Atmosphere	14.7	Pounds/Sq. In
Ampere-hours	3,600	Coulombs
Ampere-turns	2.257	Gilberts
BTU	2.930×10^{-4}	Kilowatt-hours
Centimeters	393.7	Mils
Candle/sq. cm.	3.1416	Lamberts
Degrees	60	Minutes
Dynes	1.020×10^{-3}	Grams
Dynes	1.0×10^{-7}	Joules/cm.
Ergs	7.376×10^{-8}	Foot-pounds
Ergs/sec.	1.0×10^{-10}	Kilowatts
Horsepower	3.3×10^4	Foot-pounds/min.
		Ft.-pounds/min.
Horsepower	550	Foot-pounds/sec.
Horsepower	745.7	Watts
Horsepower	42.44	Btu/min.
Horsepower (metric)	.9863	Horsepower
Inches	2.54	Centimeters
Inches	10×10^{-3}	Mils
Joule	.7376	Foot-pounds
Kilohertz	1.0×10^3	Hz
Kilowatts	1.341	Horsepower
Kilowatt-hours	3.6×10^6	Joules
Radians	5.7296×10^1	Degrees
Revolutions	6.283	Radians
Sq. Centimeters	1.973×10^5	Circular mils
Sq. Inches	1.273×10^6	Circular mils
Sq. Inches	6.452	Sq. centimeters
Sq. mils	1.273	Circular mils
Watt hours	3.6×10^3	Joules
To Obtain	Divide By	To Convert

TEMPERATURE CONVERSION

- Degrees Fahrenheit = F°
- Degrees Celcius (Centigrade) = C°
- $$\frac{F^\circ - 32}{180} = \frac{C^\circ}{100}$$

(a) To convert F° to C° : $C^\circ = \frac{5}{9}(F^\circ - 32)$

(b) To convert C° to F° : $F^\circ = \frac{9}{5}(C^\circ) + 32$

- Degrees Kelvin = K°
 $K^\circ = C^\circ + 273$

AMERICAN CONVERSIONS

To Convert	Multiply By	To Obtain
Angstrom	3.937×10^{-9}	Inches
Acres	43,560	Sq. feet
Acres	.00156	Sq. miles
Acre feet	325,900	Gallons
Barrels (dry)	3.281	Bushels
Barrels (liquid)	31.5	Gallons
Bushels	4	Pecks
Cubic feet	1728	Cu. inches
Cubic feet	7.48052	Gallons (liq.)
Fathoms	6	Feet
Gallons	.1337	Cu. feet
Knots	1.0	Naut. mi/hr
Knots	1.151	St. mi/hr
Light year	5.88×10^{12}	Miles
Miles (naut.)	6,076	Feet
Miles (naut.)	1.1508	Miles (st.)
Miles (st.)	5280	Feet
Pounds	16	Ounces
Pounds/sq. in.	2.309	Feet of water
Pounds/sq. in.	144	Pounds/sq. ft.
Tons (long)	2,240	Pounds
Tons (short)	2,000	Pounds
To Obtain	Divide By	To Convert

USEFUL CONSTANTS & DATA

c = speed of light = 2.907925×10^8 m/sec

Sound velocity: air 20°C , 1 atm: 34400 cm/sec = 1129 ft/sec = 769.5 mph

e = base, natural logs = 2.71828

γ = Euler's constant = 0.57721

$\ln x$ = 2.30259 Log x

1 electron = 1.60218×10^{-19} coul

f = Faraday constant = 9.64870×10^4 C/mol

g = gravity = 980.7 cm/sec = 32.17 ft/sec²

h = Planck constant = 6.624×10^{-27} erg sec

N = Avogadro no. = 6.02262×10^{23} /mol⁻¹

σ = Stefan-Boltzmann constant: 0.56687×10^{-4} ergs cm⁻² deg⁻⁴ sec⁻¹

NOTES:

SERVICE CERTIFICATE

Your electronic calculator is a precision electronic instrument which will serve you for many years with normal care.

CORVUS CORPORATION guarantees this calculator against defects in materials or workmanship for a period of one year from date of purchase. This guarantee applies only to the original owner registered on the attached card which must be completed and mailed, postage paid, within ten (10) days from date of purchase. *Any unit that has been repaired by an unauthorized party, tampered with, or abused is not covered under this warranty.*

IN-WARRANTY SERVICE. Unit requiring repair should be returned, postage prepaid and fully insured, to the Corvus Service Center, listed below.

OUT-OF-WARRANTY SERVICE. When out of warranty, Corvus will repair the unit for a *minimum* service charge of Nine Dollars (\$9.00). Owner will be notified of additional charges, if any. Unit should be returned, prepaid and insured, with check or money order for \$9.00 to the Corvus Service Center.

Unit should be returned in the original or a similarly constructed packaging container, via U.P.S. where possible. Receipt will be acknowledged. Enclose a letter explaining the problem, with place and date of purchase.

**Corvus Service Center
13030 Branchview Lane
Dallas, Texas 75234**

MODEL NO. _____

DATE OF PURCHASE _____

DEALER'S NAME _____

SERIAL NO. _____